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(54) **Electrically energised vibratory conveyors**

(57) An electrically energised linear vibratory conveyor drive unit of compact form, with the electrical drive circuit housed in the unit comprises a base (BP) supporting an output member (MB) with resilient members (MS, VS) to permit vibration of the output member in two directions substantially at right angles. The vibrations are caused by electromagnetic actuators (MA1, MA2, VA) and respective armatures. Electrical drive circuits and control means are housed on panels (CP1, CP2) which complete an enclosure around the actuators. The electrical drive circuits may be arranged to reduce the voltage rating required for the semiconductor devices in the circuits from the twice-supply voltage minimum required for inductive loads (the actuators).

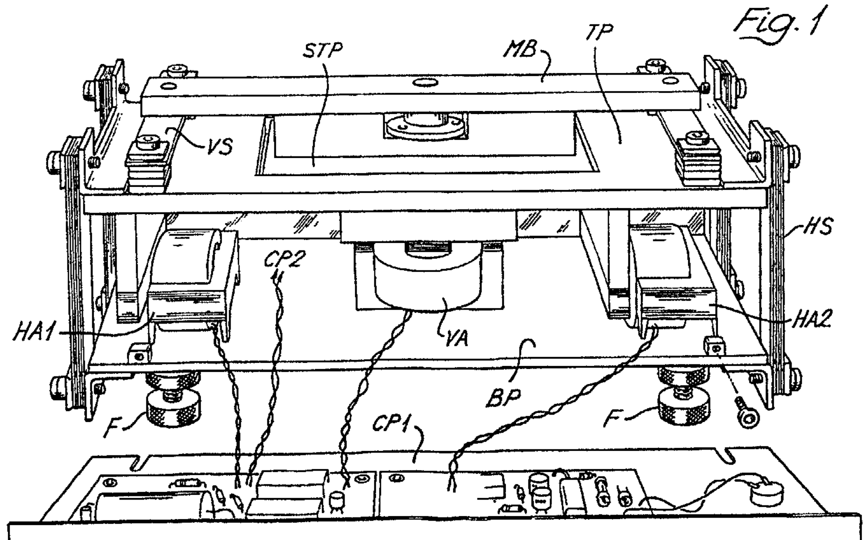

Fig. 1

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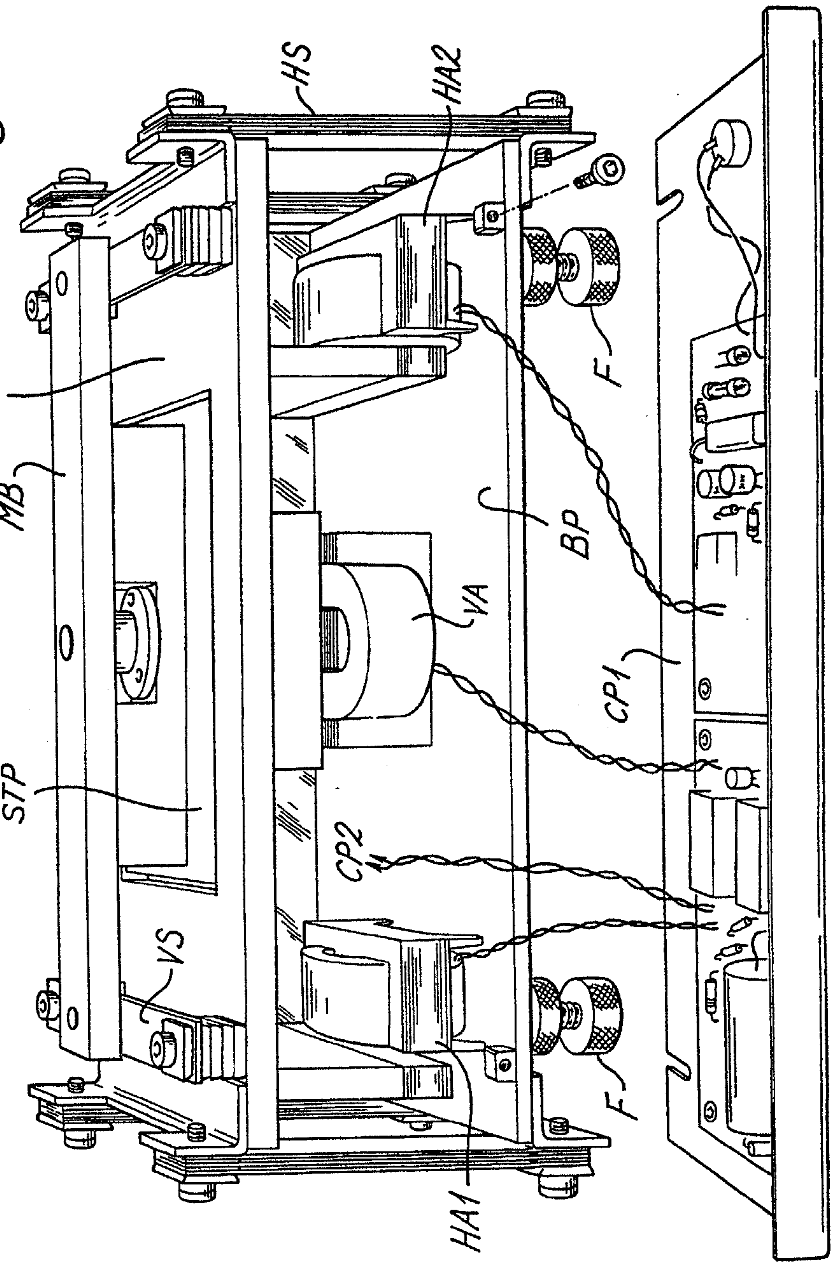
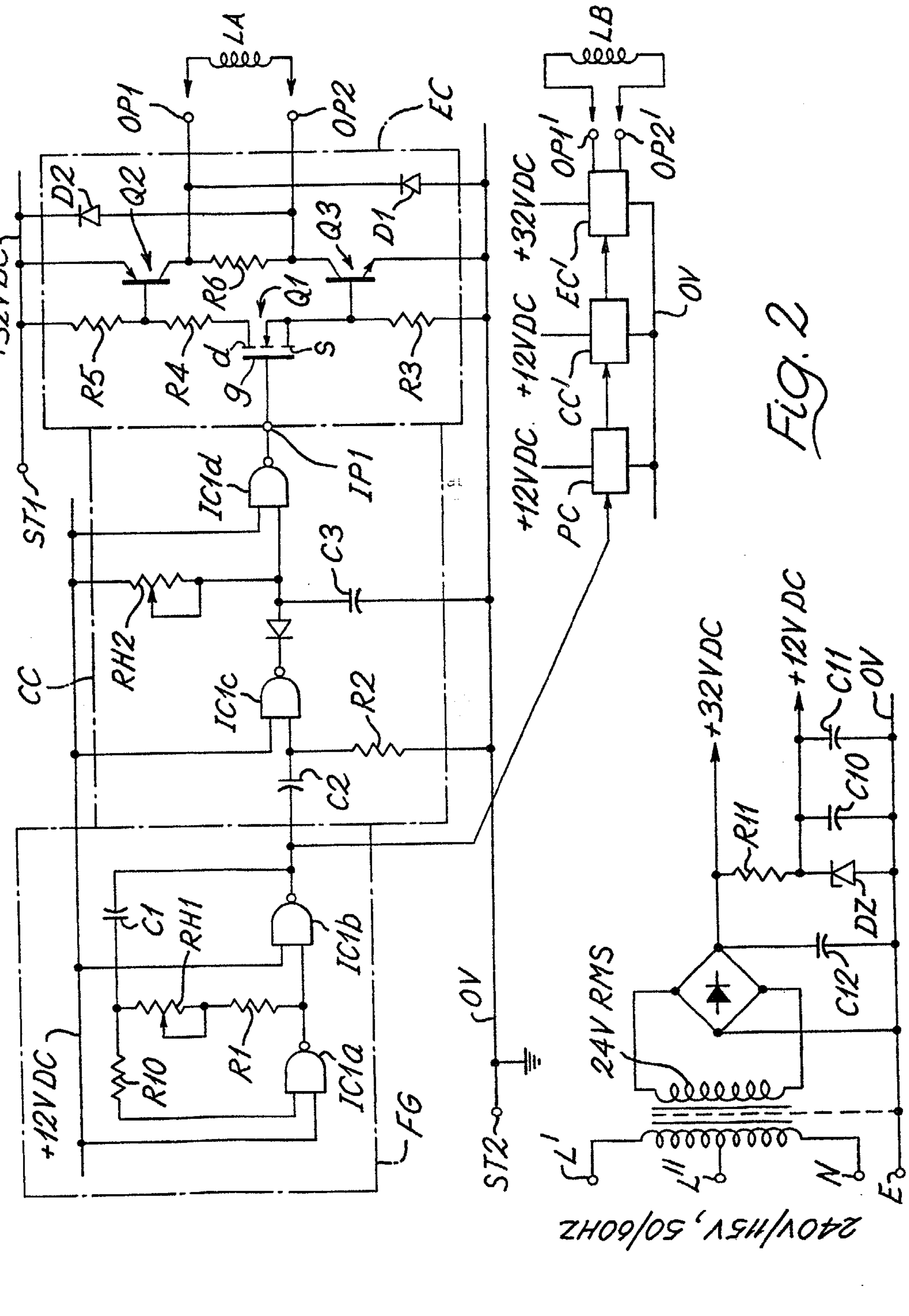
Fig. 1





LA
OP1
OP2
EC
+32V DC
D2
Q2
Q3
D1
R5
R4
R6
Q1
d
g
s
R3
IP1
IC1d
ST1
C3
RH2
CC
IC1c
R2
C2
C1
RH1
IC1b
+12V DC
R10
R1
IC1a
FG
0V
ST2
LB
OP1'
OP2'
+32VDC
+12VDC
+12VDC
EC'
CC'
PC
0V
+32V DC
+12V DC
C11
0V
R11
C10
DZ
C12
24V RMS
L'
L''
N
E
240V/115V, 50/60HZ

Fig. 2

SPECIFICATION

Electrically energised vibratory conveyors

This invention relates to electrically energised vibratory conveyors which form a reactive load and are excited at a selected frequency with controlled phase relationships.

Controlled phase vibratory conveyors, for example of the type disclosed in UKPS 1154042 provide a much better technique for conveying articles than simple vibratory conveyors. As energisation at a selected frequency, which may need to be varied, and with a controlled phase relation between two energisation senses is required electrical power is a convenient form of energisation for such conveyors. However, there are still many factors in electrical energisation which give rise to problems. These include economy of power, to avoid undue heating of windings, control of circuit voltages, to avoid damage to semiconductor devices, and control functions so that users can employ the conveyors without the need for extensive training in their use. It is also desirable to make the conveyors as compact as possible. A phenomenon affecting several of these factors is the voltage transient rising when a unidirectional current through an inductive load is interrupted. This occurs regularly because of the need to control amplitude and phase energisation. These voltage transients can appear across the active semiconductor devices used to bring about the interruption and/or reversal of current and therefore the designer must use devices with voltage ratings significantly higher, at least two or three times the voltage of the unidirectional supply. This increase the cost of the devices and therefore the cost of the equipment.

It is an object of the invention to provide an improved electrically energised vibratory conveyor of the controlled phase type.

According to the invention there is provided a linear vibratory conveyor drive unit including a rigid base frame, resilient support members extending from the base frame, and an output member supported by the resilient members, the output member to be capable of vibration in two directions substantially at right angles on the resilient support members, the unit also including first and second electromagnetic actuators on the base frame and respective first and second actuator armatures, the actuators to be energisable to act on the armatures to cause said vibration of the output member, together with electrical circuit panels mounted on the base frame to enclose the actuators and extend from the base to provide such enclosure, the electrical circuit panels supporting drive circuit elements, for applying a drive current to the actuators, and user control means to enable the setting of the frequency and/or amplitude and/or phase of the drive to the actuators together with power supply means for the circuit panel whereby vibrations of controlled phase relation are produced.

There may be a subsidiary frame connected to the resilient support members, further resilient support members extending from the subsidiary frame and connected to the output member, and the first actuator armature connected to the subsidiary frame, and the second actuator armature connected to the output member, the subsidiary frame forming part of said enclosure of the actuators.

The drive circuit may include a reverse-conductivity path for actuator drive current.

In this way an alternating current flows in the load while energy is returned to the supply when the current control devices turn off, reducing the reverse voltage across the devices.

Conveniently the current control devices are transistors, although SCR devices with associated communcation arrangements may be used. Advantageously the current control devices have a breakdown or like voltage rating of less than twice the supply voltage value. A safety resistor of high ohmic value may be permanently connected across the output terminals.

Advantageously a complementary pair of transistors, ie one n-p-n and one p-n-p, may be used as the current control devices each having its emitter connected to a supply terminals of appropriate polarity in the conductive sense of the respective forward biassed emitter base junction. Each said transistor may be of the "Darlington-pair" type.

According to a particular aspect of the invention there is provided a vibratory conveyor drive unit circuit arrangement for the energisation of a reactive load at a selected frequency with electrical energy from a unidirectional supply, the circuit arrangement including terminals for the connection of a unidirectional supply, an input terminal for the connection of a control signal and two output terminals for the connection of a reactive load, the circuit arrangement including in a first series path across the supply terminals a first polarised, active semiconductor current control device and a first, oppositely poled, diode and in a second series path across the supply terminals in reverse order to the first path a second polarised, active semiconductor current control device and a second, oppositely poled diode, the polarity sense of both paths between the supply terminals being the same and the first and second paths each providing, at the connection between the respective device and diode, one of the output terminals, the circuit arrangement further including between the input terminal and respective control terminals of the current control devices a control circuit responsive to a control signal applied to the input terminal to cause the current control devices, in operation, to together control the current passing in series through them and a connected reactive load between on and off conditions, the diodes providing a reverse polarity conductive path to the supply for current in the reactive load on the turning off of current through the current control devices.

Desirably the control circuit includes a phase splitter of the direct coupled type, although a transformer coupled type may be used, arranged to control transistor current control devices. A single field effect

transistor may be used in such a direct coupled phase splitter.

According to a particular aspect of the invention the circuit arrangement for the energisation of a reactive load may have a control signal input of a frequency of a selected value or variable over range values to permit energisation of the load in operation respectively at the selected frequency or at frequencies in the range of values.

According to a further aspect of the invention a combination of two circuit arrangements each as described above may each receive a control signal from a single frequency determining source over respective connections to the individual control signal input terminal. One or both of these connections may include a phase shifting circuit, for example a delay unit or units, to enable the relative phase of energisation from the two circuits to be controlled and/or adjusted.

Advantageously the combination of two circuit arrangements just described may be connected to energise a vibratory conveyor, one circuit providing energisation for substantially vertical vibration of the conveying surface the other for horizontal vibration of this surface.

The adjustment of relative phase of energisation permits the operation of the conveyor to be optimised for a particular working condition. Controls may also be provided for the amplitude of energisation, e.g. the ratio of on to off time of the current control devices, to permit the speed of the conveyor to be controlled. The frequency determining source may be the resilient suspension of the conveyor whose motion is coupled to the input of the circuit arrangement via a search coil or other pick-up device.

Conveniently the combination of circuit arrangements and a suitable mains energised source of a unidirectional power supply may be mounted on the frame of a vibratory conveyor in a compact unit. The unit may be provided with a suitable damping mass and supported on resilient feet as a free standing stable equipment not requiring a rigid mounting platform.

Embodiments of the invention will now be described with reference to the accompanying drawings in which:-

Figure 1 shows a vibratory conveyor assembly according to the invention;

Figure 2 is a diagram showing circuit arrangement according to the invention.

Figure 1 shows a vibratory conveyor according to the invention in which drive control of the vibration actuators is by means of an electrical circuit arrangement. The illustrated conveyor is of the linear type.

The construction of the vibratory conveyor in Figure 1 is arranged to have a compact rectangular form with all the electrical components housed inside the envelope of the conveyor. A rigid base plate BP is supported on four feet F (two only being shown) which are preferably adjustable to level the conveyor and may also be resilient, for example of rubber. The base plate has three electromagnetic actuators mounted on it (HA1, HA2 and VA) to drive a top plate TP and a mounting bar MB as now described.

Top plate TP is secured to base plate BP by four sets of spring strips, one being indicated at HS, to permit movement of the top plate in a plane substantially parallel to the base plate. This movement is produced by the action of the two actuators HA1 and HA2. Each actuator is conveniently of an E-form core carrying the energising winding and an I-form armature to co-operate with the flux from the open edge of the E-form core in known manner. The armatures are connected to the top plate TP and the cores to the base plate BP. The spring strips are secured to the base plate and top plate by suitable fastenings, eg as shown.

A sub-top plate, STP, is positioned in a space in the top plate with a small clearance between the sub-top plate and top plate. The vertical actuator VA is similar to the horizontal actuators, and of E- and I- form, but arranged to move the sub-top plate STP in the vertical direction. A mounting bar MB secures the sub-top plate STP to top plate TP via two further sets of spring strips VS.

The result of this construction is that mounting bar MB can be moved substantially parallel to base plate BP and at the same time moved towards and away from base plate BP in a regular manner. The amplitude speed and phase relation of these motions can be controlled and adjusted by an electrical circuit including elements as described above. The stiffness of the springs is also chosen having regard to operating conditions. The springs are conveniently of metal but other materials such as the general class of composites including those using or incorporating carbon fibre, glass fibre, KEVLAR (RTM) fibres and the like may be used instead. Other forms of resilient member may be used, apart from those specifically illustrated. For example a resilient member that can accommodate both the vertical and horizontal movements, eg a suitable coil spring, may be used to support the output member from the base plate. The armature arrangement shown would still be effective as these would still be within the field of influence of the respective actuator. The top plate and output member could then be one element.

The compact construction, the drive unit in Figure 1 is some 16 inches (400 mm) long and about 6 inches (150 mm) square, permits the ready incorporation of the unit into production equipment. Suitable tooling is readily fitted to the mounting bar MB for any specific use. An important feature of the unit is that the direction of conveying is readily reversed by a simple manipulation of the drive circuit controls. Thus in one application components to be placed in depressions in a surface are moved forward over the surface, which is supported on the conveyor, until the depressions are filled, then surplus components returned to the starting point by reversing the drive and the filled surface then removed. For feeding applications the speed of the conveyor, ie the rate of feed, can be adjusted over wide limits by simple adjustments of the controls of the unit.

Additionally if required a rocking or sideways motion substantially in a horizontal plane can be produced simultaneously with the other motions by additional mechanical, electro-magnetic pneumatic or other

means.

The electrical circuit is conveniently mounted on circuit panels placed on the vertical faces of the conveyor construction. One panel, CP1 is shown in Figure 1 and in this embodiment one further panel, CP2 not shown, is fitted on the opposite, large, face of the construction. If required up to two more small panels can be fitted on the short faces.

The control panels CP1 and CP2 are conveniently metal plates with a lengthwise stiffening flange and are fitted by two bolts clamping the panels to brackets on base plate BP (as shown). Electrical components and printed circuit cards can be housed on the inside of the panel below the flange. Controls for operator use are fitted to the panels.

The circuit shown in Figure 2 and described in detail below is used with one modification to operate this conveyor in one emobidment. A sensor, such as an inductor and a movable core, is fitted between top plate TP and base plate BP to detect the motion of the top plate. This motion, including the initial movement on switching on the conveyor, generates a pulse which, shaped if needed, provides the input for circuits CC and PC. The electronic components of the units PC, CC, CC', EC, EC' and PSU and the sensor are arranged on the panels with the necessary heat sinks. connectors and the like to be electrically safe and efficient and not suffer mechanical damage in use of the vibratory conveyor. Some components are indicated in outline in the Figure. The actuators are connected to the output terminals of circuits EC and EC'. Conveniently the horizontal actuators HA1, HA2 are connected in parallel directly to the terminals of circuit EC and the vertical actuator directly to the terminals of circuit EC'. It will be noted that the actuator windings are thus directly connected to the unidirectional supply and not through a transformer.

In operation of the conveyor the motion of mounting beam MB is controlled by the controls for phase (in unit PC) and level of energisation (in units CC and CC'). Frequency of horizontal and vertical fibration is set by the feedback from the sensor to the input of units PC and CC to the natural frequency of the suspension of top plate TP by springs HS.

In conventional vibratory conveyors, energised by the a.c. main supply frequency of 50 or 60 Hz as appropriate, the suspension springs are adjusted or chosen to produce vibration at the supply frequency. However it is not practical, and probably not possible, to produce vibratory conveyors for sale in quantity which are precisely set to the mains frequency for all loads. The mechanical springs generally available are not precise, consistent or stable enough for this result.

It has also been found that a precision of ±1% is desirable for the matching of the horizontal and vertical vibration frequencies to permit efficient conveyor operation. Such precision is beyond mechanical springs both initially and over some period of use. However use of electronic drive and especially with feedback control permits such precision to be attained and maintained even over a wide operating temperature range. The energisation frequency is set by the conveyor and is not arbitrarily set by the local supply frequency therefore more efficient, quieter, faster operation is possible.

Figure 2 shows in detail a circuit arrangement according to the invention identified by outline EC. The circuit of Figure 2 is for use on a nominally 32 vdc supply with ancillary units supplied at 12 vdc (stabilized).

The circuit arrangement EC of Figure 2 includes a complementary pair of active semiconductor devices, specifically transistors Q2 and Q3 to control the current supplied in operation to a load such as LA connected to output terminals OP1, OP2. Each device is rated to withstand the full supply voltage and to control the full current to be supplied to the load, some 3A in this embodiment. Associated with the transistors are two diodes D2, D3 with a similar current rating. Suitable devices are transistor types 2N6284 and 2N6285, a complementary pair of Darlington-pair devices, and conventional rectifier diodes of 6A rating, such as the "Radio-spares" type, or 1N5402.

In this embodiment each transistor is connected in a respective series path with one diode directly across the 32 v supply terminals ST1, ST2. Each transistor is adjacent to one supply terminal so the devices are in reverse order in one path compared to the other. Preferably the transistors are connected with their emitter base junctions adjacent to the respective supply terminals so that control signals can be applied between a supply terminal and the base of the transistor. One of the output terminals OP1, OP2 is at the connection point of the diode and transistor in each path. A safety resistor R6 may be permanently connected across the otherwise open circuited output terminals and this resistor also assists testing. A suitable value is 10^5 ohms.

In operation it is required that both transistors Q2, Q3 operate "in phase". To control these transistors a direct coupled single transistor phase splitter is provided. The source and drain terminals of a small power field effect transistor Q1 are connected into a series resistive path across the supply terminals formed by resistors R3, R4 and R5 as shown. Resistor R4 is conveniently 10^3 ohms and resistors R3 and R5 each 10^4 ohms. The gate terminal of transistor Q1 is connected to the input terminal IP1 of the circuit EC. The resistors R3 and R5 are included in the emitter base circuits of transistors Q2 and Q3 respectively as shown. In operation a suitable control signal applied to input terminal IP1, using supply terminal ST2 as a common terminal, will turn transistor Q1 "on" so that current flow in resistors R3, R5 will produce suitable emitter base potentials in transistors Q2, Q3 to bring them into a conducting condition. Clearly when transistor Q1 is "off" the emitter base potentials of transistors Q2, Q3 will be too small to bring them into a conducting condition so these transistors also will be "off".

In operation it is the intention that transistors Q2, Q3 will either be "off" or turned "on", to the saturated condition if possible, as this is a clearly defined condition and can be obtained without too close control on device parameter tolerances and operating conditions. However, other modes of operation may be used eg

controlling the emitter base potentials of devices Q2, Q3 to vary the current in the devices in the "linear" mode rather than a "switching" mode as just described.

Operation in the "switching" mode with a connected reactive load LA will now be described. The reactive load in this case is an inductor, actually the winding of an electromagnetic actuator of a vibratory conveyor. This load is to be energised at a rate of a few tens of times a second, say 15 to 60 times. Accordingly a suitable control signal, such as a train of 10 volt pulses with a variable repetition rate in this range, is assumed to be connected to input terminal IP1 to cause transistor Q1 to turn on and off at this rate. The supply terminals are energised with a 32 v supply which is nominally direct current but can conveniently be rectified alternating (50 Hz) current only partially smoothed by the use of a single large electrolytic capacitor. Clearly care must be taken that the peak value of any supply variation does not exceed the voltage rating of the transistors.

On transistor Q1 being switched "on" by the input control signal transistors Q2, Q3 will in their turn be switched on together and permit current from the supply to pass through the connected inductive load (LA). On transistor Q1 being switched "off", eg by the input control signal going to zero at the end of a pulse, current will cease to flow through transistors Q2, Q3, as resistors R3, R5 act to hold off these transistors. However, energy will still remain in the inductance of the reactive load and will attempt to maintain the current flow, in the well known manner. This attempt would usually produce excessive voltages at the transistor collectors which could breakdown the devices by exceeding their voltage rating. In known arrangement the transistors are therefore rated at two or three times the supply voltage and protection diodes, snubber circuits and multiple windings are often connected between collector and emitter of the transistor.

In the circuit embodying the invention the production of excessive voltages on the switching off of load current from the supply is avoided by the provision of diodes D1, D2 connected in a particular relation with the load and the current control devices. On exmaining the circuit diagram it will be seen that if terminal OP2 rises to a potential only slightly (say 0.5 to 1.0 volt) more positive than the supply terminal ST1 diode D2 becomes conductive as does diode D1 if terminal OP1 falls to a potential slightly more negative than supply terminal ST2. The effect of voltages induced by the switching off of current supply is therefore to connect the reactive load, in reverse, across the supply terminals. The effect can be regarded as discharging the energy in the load into the supply.

On transistor Q1 next being turned "on", by the next pulse of the input control signal, transistors Q2, Q3 again permit current to flow from the supply into the load, continuing the energisation of the electromagnetic actuator into the next cycle of operation. Diodes D1, D2 are reverse biased firmly into the non-conductive condition once transistors Q2, Q3 are "on".

In addition to the above described control of induced voltages by diodes D1, D2 the circuit embodying the invention provides further advantages over other circuits to energise reactive loads at a variable frequency of some tens of times a second, or higher, up to say a few hundreds of times a second. If a simple diode clamp is used across a device such as a transistor the current decay rate after siwth off is much slower than the rate of current growth at siwth on. Accordingly instead of the current returning to zero between each "on" pulse it falls only to an intermediate value. The result is a significant standing current in the switching device and the load which wastes power, increases the load on the device and reduces the effectiveness of the load, such as a vibrator. The present invention overcomes this problem.

To improve the effectiveness of a vibratory actuator it is convenient to "tune" the circuits to the vibration frequency. However if this is done with a simple, single ended, current control arrangement additional components are needed to "tune", which reduces the range of frequencies for which the actuator is efficient and the high voltage on switch off is required to improve the rundown of current after switch off. A double wound actuator drive circuit has been proposed, UKPA 2009177, by which energy can be returned to the supply from a secondary winding but this still requires devices rated at over twice the supply voltage and the leakage inductance between the windings can create transients which aggravate the load on the devices.

The present arrangement has the frequency indpendent feature of the double wound arrangement to an even greater degree, avoids the leakage inductance problems and overcomes the high voltage stress problem of all earlier techniques. The arrangement can also work with a single sided supply instead of the centre tapped typres frequently proposed for semi-conductor inverter duty. It has been found that the radiation of radio frequency interference (RFI) is also much reduced.

If required, the phase splitter can be of the transformer type or coupled to the base of the current control devices by a transformer to provide isolation from high voltages, eg 200 to 300 v or more, which may be used in the final stage when higher output powers are required. The reduced voltage stress on the devices permits the use of such high voltages with readily avalable devices and enables higher power levels to be reached at a given current and inductor construction, which generally depends on current rating not voltage at these values.

Figure 2 also shows ancillary circuits which may be used with the energisation circuit. As mentioned above a source of pulses at a controllably variable frequency is used to operate the circuit EC. Means for controlling the amount of current supplied to the load may also be required. Suitable circuit elements are illustrated in Figure 2. Unit FG indicates a frequency generator. Two NAND gates (IC1a, IC1b) of integrated circuit IC1 are cross connected to form an oscillator whose frequency is set by resistors R1, RIO and RH1 and capacitor C1. Adjustment of the generated frequency is by varying variable resistor RH1. The circuit is supplied with

stabilised 12 vdc.

The output of frequency generator FG is a rectangular wave of approximately 1:1 mark/space ratio (typically five units of time at the "high", greater than +6 v, logic level and four units at the "low", OV, logic level) with a period controlled by resistor RH1. The output of FG is supplied to an input of unit CC which is arranged to control the duration of the flow of current in circuit EC. In unit CC the output waveform of FG is differentiated in the network of capacitor C2, resistor R2 to produce a train of positive-going edges, one for each level output of the frequency generator. The negative-going edges are clipped by the input circuit of IC1c. IC1c is a NAND gate with one input permanently enabled by a connection to +12 vdc. The other input receives the positive-going edges from C2/R2 and is held in the "on" condition, output logic "low", only for as long as the edge and its subsequent decay exceeds the logic threshold. This is only a small fraction of the wavelength of the rectangular wave. The output of IC1c is thus normally "high" and only "low" for a short time in each cycle from the frequency generator. The output of IC1c is connected via a diode D1 to the junction of a variable resistor RH2 and a capacitor C3 connected in series across the 12 v supply with the other end of the capacitor to the 0 v line.

When the output of IC1c goes "low" the gate is "on" and quickly discharges the capacitors C3 via diode D1 and the current sinking capaicty of the "on" gate. The junction of RH2 and C3 is also connected to one input of a further NAND gate IC1d. The other input of this gate is again permanently enabled by a connection to +12 vdc. The discharge of capacitor C3 is very rapid and the gate IC1d is thus rapidly put in the "off" condition and held there, even though gate IC1c has reverted to the "off" condition, until capacitor C3 has been charged through resistor RH2 to the logic transition level of gate IC1d, diode D1 is in the blocking condition now.

The output of gate IC1d is applied to the input of the circuit EC described above. When gate IC1d is "on" the output is logic low and transistor Q1 is off. When gate IC1d is "off" the output is logic high and transistor Q1 is on, turning on transistors Q2, Q3 to pass current from the 32 v supply through a connected load. Gate IC1d is "off" from the discharge of capacitor C3 until it recharges to the logic transition level, about 6 v, and enables the connected input of IC1d to turn the gate "on" and thereby turn transistors Q2, Q3 off via transistors Q1. The length of time, in each cycle from frequency generator FG, for which transistors Q2, Q3 are on is thus set by the recharge time of capacitor C3 via variable resistor RH2 a higher setting of the resistor increasing the length of this on time. A fixed resistor may be included in series with RH2 to set the minimum on time while the maximum value of RH2, and any fixed resistor, may be chosen to set the maximum on time to less than a whole cycle from FG.

The frequency at which the circuit EC is turned on is therefore set by resistor RH1 and the proportion of time for which circuit EC remains turned on is set by resistor RH2.

A power supply PSU provides suitable 12 v and 32 v supplies, with a common zero, from a 240 or 115 volts 50 or 60 Hz supply mains if required.

Other ancillary circuits are shown in Figure 2 to permit the control of another circuit EC', identical to circuit EC, to operate at the same frequency, set by resistor RH1, but at a different phase and on to off ratio. Circuit CC', identical to circuit CC, is operable in the same way as circuit CC to control the current in flow time in circuit EC'. A further circuit, PC, is provided for the control of the phase of current flow in circuit EC' with reference to that in circuit EC.

Circuit PC is the same as circuits CC and CC' except that the value of capacitor C3 is increased, typically being doubled to 0.47 microfarad. This increases the time taken to charge the capacitor via the variable resistor, RH2, and therefore increases the possible interval between the positive-going edge at the output of generator FG and the final NAND gate in circuit PC being turned "off" to produce an output of a positive-going edge to act on circuit CC' to turn on the current in circuit EC'.

The effect of this adjustable interval is to vary the phase of the operation of circuit EC' with respect to that of circuit EC. The circuit PC provides a delay of up to one cycle at the lowest frequency of FG and this affords a phase shift of up to 360° between the two circuits.

Circuits PC, CC' and EC' are shown in block form; the only difference is the value of the timing capacitor in circuit PC, mentioned above. Values for components on Figure 2 are given on the accompanying list. IC1 is type 4011 and the bridge rectifier in unit PSU type KBPC 602. Clearly alternative values and devices are usable, or will be needed for different voltages, while gate turn off devices may be suitable alternatives for transistors Q2, Q3.

Resistors		Capacitors		Semi-conductors	
R1	10K	C1	0.22μF	Q1	VN10KM
R2	100K	C2	0.001μF	Q2	2N6285
R3	10K	C3(CC)	0.22μF	Q3	2N6284
R4	1K	C3(PC)	0.47μF	D1	1N5402
R5	10K	C3(CC')	0.22μF	D2	1N5402
R6	100K	C10	0.1μF	DZ	12 v zener
R10	1M	C11	47μF		
R11	560	C11	4700μF		

As mentioned above the circuit arrangements can be used to drive a vibratory feeder. It has been found that with the low power level required to energise the feeder, because of the improved efficiency of the drive, the addition of a mass of material at the base of the feeder greatly reduces the vibration applied to the surface on which the feeder is placed. A mass of a few tens of pounds say 30 to 60 pounds attached to the base of a feeder of the size described above the permits the feeder to be used as a free standing unit on almost any surface strong enough to support the unit. Hitherto it has been considered necessary to mount such feeders on rigid or heavy plinths or bases. The use of resilient feet, say of medium hard rubber, with the added mass has been found to produce a feeder or conveyer unit which remains in position when free standing in operation at full power. The unit is also very quiet in operation which will reduce "acoustic pollution" when the unit is in use in quantity in, say, an assembly line.

CLAIMS

1. A linear vabratory conveyor drive unit including a rigid base frame, resilient support members extending from the base frame, and an output member supported by the resilient members, the output member to be capable of vibration in two directions substantially at right angles on the resilient support members, the unit also including first and second electromagnetic actuators on the base frame and respective first and second actuator armatures, the actuators to be energisable to act on the armatures to cause said vibration of the output member, together with electrical circuit panels mounted on the base frame to enclose the actuators and extend from the base to provide such enclosure, the electrical circuit panels supporting drive circuit elements for applying a drive current to the actuators and user control means to enable the setting of the frequency and/or amplitude and/or phase of the drive to the actuators together with power supply means for the circuit panels, whereby vibrations of controlled phase relation are produced.

2. A conveyor drive unit according to Claim 1 including a subsidiary frame connected to the resilient support members, further resilient support members extending from the subsidiary frame and connected to the output member, and the first actuator armature connected to the subsidiary frame and the second actuator armature connnected to the output member, the subsidiary frame member forming part of said enclosure of the actuators.

3. A conveyor drive unit accoridng to Claim 1 or Claim 2 in which the electrical drive circuit includes means to provide a reverse conductivity path for an actuator drive current effective on the ending of an application of current to an actuator, whereby electrical energy can be returned to the power supply means.

4. A conveyor drive unit according to Claim 3 including a power supply means having an output at a first rated voltage and in which the drive circuit elements for applying said drive current have a breakdown or like voltage rating of less than twice said first rated voltage.

5. A conveyor drive unit according to Claim 1 or Claim 2 including a circuit arrangement for the energisation of a reactive load at a selected frequency with electrical energy from an unidirectional supply, the circuit arrangement including terminals for the connection of an unidirectional supply, an input terminal for the connection of a control signal and two output terminals for the connection of a reactive load, the circuit arrangement including in a first series path across the supply terminals a first polarised, active semiconductor current control device and a first, oppositely poled, diode and in a second series path across the supply terminals in reverse order to the first path a second polarised, active semiconductor current control device and a second, oppositely poled diode, the polarity sense of both paths between the supply terminals being the same and the first and second paths each providing, at the connection between the respective device and diode, one of the output terminals, the circuit arrangement further including between the input terminal and respective control terminals of the current control devices a control circuit responsive to a control signal applied to the input terminal to cause the current control devices, in operation, to together control the current passing in series through them and a connected reactive load between on and off

conditions, the diodes providing a reverse polarity conductive path to the supply for current in the reactive load on the turning off of current through the current control devices.

6. A conveyor drive unit according to Claim 5 in which the control circuit includes a phase splitter of the direct coupled type arranged to control transistor current control devices.

7. A conveyor drive unit according to Claim 6 in which a single field effect transistor is used in said direct coupled phase splitter.

8. A conveyor drive unit according to Claim 1 or Claim 2 in which the control means provides a control signal input of a frequency of a selected value or variable over range values to permit energisation of the conveyor in operation respectively at the selected frequency or at frequencies in the range of values.

9. A conveyor drive unit according to Claim 1 or Claim 2 in which two sets of drive circuit elements, for respective actuators, each receive a control signal from a single frequency determining source over respective connections to individual control signal input terminals.

10. A conveyor drive unit according to Claim 9 in which one or both of said connections includes a phase shifting circuit, such as a delay unit or units, to enable the relative phase of energisation from the two circuits to be controlled and/or adjusted.

11. A conveyor drive unit according to Claim 1 or Claim 2 including two sets of drive circuit elements one set providing energisation for substantially vertical vibration of a conveying surface the other for horizontal vibration of this surface.

12. A linear vibratory conveyor drive unit substantially as herein described with reference to Figure 1 or Figure 2 of the accompanying drawings.

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